High Performance Polymer Photovoltaics

Rafael Verduzco, Seth Darling, Kendall Smith, and Yen-Hao Lin

Summary

With the support of the Shell Center for Sustainability, we made significant progress in our goal to develop block copolymer-based photovoltaics. The results of our work in the past year led to three published articles, one article currently under review, and three proposals for follow-up funding from the National Science Foundation, the Office of Naval Research, and the Department of Energy. Results from this work were presented at the American Physical Society March Meeting, the Polymer Physics Gordon Conference, and the Annual Meeting of the American Institute of Chemical Engineering.

Accomplishments

In work authored by Yen-Hao Lin entitled “Supramolecular Block Copolymers” and published in Macromolecules 2012, 45, 6571, we reported the synthesis and characterization of conjugated block copolymers with hydrogen-bonding associations. This represents the first example of block copolymers held together with non-covalent forces.

In a second article by Yen-Hao Lin (Synthesis and Crystallinity of All-Conjugated Poly(3-hexyl thiophene) Block Copolymers” Polym. Chem. 2013, 4, 229) we reported an improved synthetic technique for all-conjugated block copolymers. The work resulted in simplified route for the synthesis of all-conjugated block copolymers and was featured on the journal cover.

In work with Chloe Kempf, a Rice Undergraduate student, as the primary author, we reported the use of “click” chemistry to synthesis a series of block copolymers and their self-assembly in water “Poly(alkylthiophene) block copolymers prepared via externally initiated GRIM and click coupling,” accepted for publication in Polym. Chem., DOI:10.1039/C3PY21098G.

In an article submitted to Macromolecules and currently under review, we describe a study of crystallization in a series of all-conjugated block copolymers. We report the unprecedented finding that crystallization is dominated by one block or the other; co-crystallization of both polymer blocks appears to be suppressed in all-conjugated block copolymers.
Finally, in recent results in collaboration with Enrique Gomez at Penn State University, we have achieved record performance in an all-conjugated block copolymer device. Materials synthesized in our lab (shown below) demonstrated a 3% power conversion efficiency. This triples the previous record of 1% for a block copolymer device and surpasses the previous record for an all-polymer device.

Future Work

Future work will build upon these recent achievements. Motivated by the exceptional performance of the materials shown above, we are studying how we can further improve the performance by developing new materials with broader absorbance and better charge-carrier mobilities.

We are actively pursuing follow-up funding using the results generated over the past year. This includes proposals to the National Science Foundation, the Office of Naval Research, the Welch Foundation, the Department of Energy, and the Army Research Laboratory.